**Industrial water management: Paving the way for new processes, sustainable production and site security**

*Water is key for the process industry: whether as a coolant or solvent, as a reagent or product component. Chemical and pharmaceutical production is constantly evolving - hydrogen, digitalisation, recycling, new production processes. What does this mean for industrial water management?*

CO2 neutrality, hydrogen production, power-to-X processes, circular economy and zero pollution are currently at the top of the process industry's agenda. Water is an irreplaceable resource, especially for chemical and pharmaceutical production. If industrial water management can be successfully integrated into production and site management, process efficiency can be increased, circular solutions become possible and the transformation towards a sustainable process industry progresses. In addition, close integration of production and industrial water management strengthens the competitiveness of companies and sites, reduces the risk of production downtime and increases investment security in corporate development. The increasing water stress at many process industry sites means that business success is increasingly dependent on efficient industrial water management.

**Water as the key to hydrogen production**

The utilisation of renewable energies and their storage in the form of hydrogen or derived products is one of the most important prerequisites for a climate-neutral process industry. A growing number of initiatives in various sectors are accelerating the expansion of capacities to produce and utilise hydrogen: More than 1,400 international hydrogen projects, as well as many reference projects in Germany such as Aquaventus, H2Giga, H2Mare or Kopernikus emphasise this development. While industry uses hydrogen as an energy storage medium or for high-temperature processes, R&D projects are focussing on hydrogen infrastructure, mass production of electrolysis technologies and the synthesis of basic chemicals based on hydrogen.

Commercially available electrolysers require around 10 to 17 kilograms of deionised water to produce one kilogram of green hydrogen. Green or sustainable energy, the basis for green hydrogen, can be produced particularly economically in sunny or windy regions. However, the regions with the highest potential for renewable energies are usually also the regions where there is a high level of water stress and therefore a water risk. Once the local resources have been used up, this has an irreversible impact on the region. Alternative water resources for hydrogen production are therefore becoming increasingly important. Examples include desalinated water and water reuse. A growing number of seawater desalination plants leads to new challenges in terms of wastewater discharge (emissions into the sea) and opens up opportunities for the utilisation of brines and concentrates, for example. The production of green hydrogen will increase in the future. As a result, water will have to be utilised and reused more efficiently in the production process, especially cooling water and wastewater streams. This is where optimised, integrated water management comes into play.

More and more new hydrogen projects are focussing on a direct conversion of hydrogen into basic chemicals and chemical energy storage, such as ammonia, methane or eKerosene. The thermal energy released in this production step can be made available to other processes. Thermal desalination technologies with higher efficiency, as well as biological wastewater treatment, can thus benefit from the available thermal energy and move further into focus. This development is not only relevant for the hydrogen economy; new membrane separation processes or extensions to biological water treatment can also have a positive impact on industrial water management in terms of process and energy efficiency.

"Water is the key to realising large-scale plants for the production of green hydrogen and its downstream products such as methanol or ammonia. That's why we need to think about integrated water management together with strategies for renewable energies and hydrogen production right from the start. This is the basis for a successful green hydrogen economy. Plant engineering and process technology, as we will see at ACHEMA 2024, will make a decisive contribution to this," says Dr Thomas Track, Head of the Water Management Subdivision at DECHEMA e.V.

In addition to renewable energies, efficient and robust water-related solutions are therefore needed:

* Expertise and planning to produce hydrogen / follow up PtX products and water management must go hand in hand.
* (Wastewater) treatment technologies and management concepts must be tailored to inland, coastal and marine production scenarios.
* The recycling of water and material flows must be optimised.

**Water for the circular economy in the process industry**

Circular innovations are changing industry worldwide and are currently at the top of the process industry's agenda. The transition to a circular economy focussing on the entire product life cycle from raw material procurement to recycling requires a comprehensive transformation of industrial processes and structures towards climate neutrality and long-term competitiveness. The associated challenges for industry also have an impact on industrial water management.

"The value chain of future circular production will have a high proportion of processes in the aqueous phase," says Dr Christoph Blöcher, Head of Infrastructure Processes, Materials & Corrosion, Covestro Deutschland AG. "Water management must therefore be taken into account in process development right from the start. New approaches are required for the aqueous residual streams in order to recover chemical energy and valuable substances, such as nutrients."

In addition to its traditional role in industrial production and cooling, water as a resource is therefore increasingly coming into focus in new industrial fields of application. Processes for (waste) water treatment will change overall, from water purification to the utilisation of residues, water and its thermal energy through recovery.

Chemical recycling processes as well as processes based on renewable raw materials and biotechnological processes generate aqueous residual flows that are characterised by a high-volume flow and high organic and salt loads. The composition of the process water in recycling processes therefore poses completely new challenges. Examples include the chemical recycling of plastics, composite materials (e.g. high-performance lightweight materials or composites for electromobility) or polymetallic composites in electronic components, battery cells or lightweight alloys. In addition to chemical processes, various biotechnological approaches are being pursued to recycle plastics, including the use of enzymatic processes. These are often associated with increasing water requirements. To meet these requirements, comprehensive technological approaches and processes for the treatment of wastewater must be developed, tested and implemented.

**Pharmaceuticals and hydrogen production: water for injection and ultrapure water**

Pharmaceutical production has become even more important, not least due to the coronavirus pandemic, and innovations have been launched. For the pharmaceutical industry, parts of industrial biotechnology and the laboratory sector, industrial water management is focussing on water for injection (WFI) and ultra-pure water.

Rising investment and maintenance costs, high energy prices and increasing consumer concerns about the environmental impact of production and packaging residues are causing many pharmaceutical companies to rethink their approach to more sustainable production options. Since 2017, it has also been permitted in Europe to produce water for injection no longer exclusively using distillation, but also using membrane processes, for example. This process has been standard in the USA and other parts of the world for many years. This production variant is not only more flexible and energy-efficient, for operators of WFI systems it also offers advantages in terms of investment and production costs, space requirements, service and maintenance services, as well as the ability to expand the systems in terms of production volume and a wide range of process engineering options.

Market analyses such as those by Transparency Market Research see the current global market for water for injection purposes at over USD 20 billion (2021), with growth prospects of over USD 50 billion in the next ten years.

The global trend towards a green hydrogen economy is leading to an increasing demand for water for the operation of electrolysers. The focus here is on water treatment systems and closed-loop purification systems for ultra-pure water. This trend also suggests a positive development of the market for ultrapure water systems for electrolysis.

"The current demand for ultrapure water systems is still characterised by the boom in the pharmaceutical industry in recent years and is receiving an additional boost from the current strong expansion in the production of green hydrogen," says Dr Eva Bitter, Managing Director of EnviroFALK PharmaWaterSystems GmbH.

**Optimising water management: Digitalisation, industrial intelligence and sensor-based process control**

Digital technologies are used to increase efficiency, reduce resource consumption and close material cycles. In the process industry, this also applies to the interface between water management and industrial production. Be it to establish modular, dynamic and flexible production approaches or to realise supply security through integrated water resource management: Collecting the necessary information and processing the resulting data streams is only possible by using digital tools.

Especially at the interface between industrial production and industrial water management, complex plant structures can be linked with IoT/IIoT-based devices and sensors for monitoring and control. The processing (e.g. with artificial intelligence) of large amounts of data (big data) can be outsourced in a cost-flexible manner (edge vs. cloud). These technologies are essential for the processing and efficient utilisation of resources. The information obtained can be secured in distributed ledgers (DLT) and thus form the basis for automated and transparent contracts (smart contracts). All these technologies bring suppliers, manufacturers and customers closer together and enable an overview along the supply chain. ACHEMA 2024 will showcase these links in the exhibition with its Digital Hub and measurement, control and process control technology.

"Digitalisation in the water industry ("Water 4.0") has become a buzzword and will lead to far-reaching changes in both the public and private sectors. For some time now, companies have been faced with the challenge of strategically adapting to the new digital world and rethinking their strategy, business models and cultures to this end. If an organisation fails to take this important step, it will lose its future viability and competitiveness," says Christian Gutknecht, Water Sector Manager at the Endress+Hauser Group.

Water is a crucial resource for the process industry and energy supply, but it is also one of the most endangered resources. Especially in the context of the energy transition and the use of renewable energies, the interaction of individual processes is crucial. This is where digital twins can play a decisive role. They can simulate the increased demands on plant dynamics in real time, adapt production and thus secure a decisive competitive advantage. The increasing demands on supply security, product quality and plant efficiency can only be met through the digital transformation of traditional production. The trend is being led by numerous consortia. These are developing globally applicable standards for communication and plant safety, thereby accelerating the digital transformation.

**Conclusion**

The wide variety of processes and technologies - hydrogen production, circular economy, pharmaceutical production and digital integration – clearly shows that efficient water management is a central component of the process industry. This applies across all scales, from plant to operation and site to the entire company. In contrast to the energy and raw material base of the process industry, there are narrow limits to the substitution of water in industrial utilisation. Only by an intensive interaction industrial production and water management can realise their full potential for a green, circular and net-zero economy.

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**About ACHEMA**

ACHEMA is the world forum for chemical engineering, process engineering and biotechnology. The world’s leading show for the process industry takes place every three years in Frankfurt. The spectrum ranges from laboratory equipment, pumps and analytical devices to packaging machinery, boilers and stirrers to safety technology, materials and software, thus covering all the needs of the chemical, pharmaceutical and food production industries. The accompanying congress, featuring scientific lectures and numerous guest and partner events, complements the wide range of exhibition themes. The next ACHEMA will take place from 10 to 14 June 2024 in Frankfurt am Main. [www.achema.de/en](http://www.achema.de/en)